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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of any patent issued thereon.

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Non-Return Valve

The invention relates to a non-return valve having a valve housing which defines an interior fluid passage extending along the longitudinal axis of the passage, a seat element which is positioned in the passage and defines a valve seat, and a detent element which may be moved axially for movement against the closing force of a closing spring in the passage between a detent position adjoining the seat element and opening positions raised above the valve seat on the detent element.

Fluid-engineering assemblies frequently contain non-return valves as components of the control systems of the assemblies. It has been found in many practical applications that control in use of non-return valves with a fixed opening pressure is not trouble-free because of the variable configuration of the assemblies (with regard to pressure level, volume flow, site of installation, and the like). In such a case a relevant non-return valve must be replaced with a valve set for the opening pressure adapted to the assembly when the assembly is placed in operation on site. This entails burdensome and time-consuming conversion measures which in some instances must be executed repeatedly because the opening pressure required in individual cases cannot be accurately foreseen. A remedy could be found in this instance in the form of a non-return valve that could be adjusted as a function of the opening pressure.

Currently available adjustable non-return valves cannot, however, meet the requirements to be set. Disclosed valves with adjustable opening pressure are configured as pressure control valves. Aside from the fact that pressure control valves are not well suited for the purpose with respect to adjustment ranges, pressure stages, and temperature range, the chief problem encountered with pressure-control valves is that the flow of fluid is diverted at an angle of 90° downstream from the adjustment device, so that fouling particles may be deposited on the valve seat in the event of fouling-laden fluids and may then cause the valve to fail.

The object of the invention is to create an adjustable non-return valve which, like the disclosed non-return valves, operates with no deflection of the flow of fluid (input/output and direction of action of the valve on one longitudinal axis), one in which the opening pressure may be adjusted without modifying the structural length of the valve.

It is claimed for the invention that this object is attained in the case of a non-return valve of the type indicated in the foregoing in that the valve housing is in the form of a guide along which the seat element may be displaced axially into various adjustment positions which correspond to the desired prestresses of the closing spring and accordingly the desired adjustments of the magnitude of the closing force of the closing spring.

A non-return valve with axial fluid passage is made available, one which permits adjustment of the opening pressure optimal for operation of the assembly, so that no replacement of the valve for adaptation is necessary. The non-return valve may be configured for desired pressure adjustment ranges by appropriate design of the closing spring. Consequently, a non-return valve the adjustment range of which extends over the anticipated ranges of opening pressure desired may be selected for installation in a suitable assembly.

In especially advantageous exemplary embodiments of the invention a displacement device which may be actuated from the exterior of the valve housing is provided for control of the axial adjustment positions of the seat element. It accordingly permits adjustment of the opening pressure of the valve when installed under the prevailing operating conditions, without the need for installation operations.

In exemplary embodiments distinguished by especially simple and compact design the interior wall of the valve housing restricting passage forms the guide for the displaceable seat element, which is in the form of an adjustment piston having a coaxial interior passage the edge of which facing the detent element forms the valve seat for a detent element having one valve element.

In such exemplary embodiments the displacement device which may be actuated from the exterior of the valve housing to adjust the opening pressure is configured so that the wall of the valve housing forming the guide of the adjustment piston has at least one slot opening extending in the axial direction. A control pin extends through this opening; its interior end is seated in a radial hole of the adjustment piston and its exterior section projects outside the valve housing. The configuration may be such that the projecting outer section of the control pin operates in conjunction with a positioning mechanism which may be designed in accordance with the requirements and areas of application. A manually operated positioning device may be provided in addition to the controllable linear drives, a device such as a positioning nut on the valve housing, for example.

With a configuration of the positioning device such as this two diametrically opposite slot openings are provided, preferably in the valve housing, for two diametrically opposite control pins of the displacement device. In this instance the force of displacement for adjustment processes is introduced by way of the positioning nut to two diametrically opposite positions in

the displaceable adjustment pistons serving as seat elements, so that the adjustment processes may be carried out with precision and with no danger of canting.

By preference the displacement device has two positioning nuts between which the section of the control pins projecting outward is contained. Not only may the control pins and the adjustment piston be adjusted in both adjustment directions, but the adjustment may be secured by locking the positioning nuts in a simple and reliable manner.

In advantageous exemplary embodiments the spring-loaded locking element, the valve element of which interacts with the valve seat on the adjustment piston, is guided axially displaceable on a guide element present in the passage of the valve housing. The length of the displacement path made available for the detent element by this guide is great enough so that an adequate displacement path is available as opening lift of the detent element in all the adjustment positions of the adjustment piston involved.

By preference the displacement device, which may be operated from the exterior of the valve housing and controls the axial adjustment positions of the adjustment piston serving as seat element, is provided with a display device which provides a position display and accordingly an indication of the adjusted opening pressure. In exemplary embodiments in which the displacement device has positioning nuts on the valve housing provision may be made for a visible marking or scale along the exterior of the valve housing from which the location of the positioning nuts may be read.

The invention will be described below with reference to an exemplary embodiment shown in the drawing, in which the non-return valve claimed for the invention is shown in detail.

- The single figure presents on an approximately actual scale a longitudinal section of the exemplary embodiment of the non-return valve claimed for the invention.

A valve housing 1 made of hexagonal stock has on one end an interior screw-in threading 3 which defines an end section of a fluid passage 7 concentric with the longitudinal axis 5. Adjacent to the hexagonal section of the valve housing 1 containing the interior threading 3 is a section 9 cylindrical both on the exterior and the interior into the end section 11 of which a connection adapter 13 is forced which forms a second fluid connection, an interior screw-in threading 15 being provided which corresponds to the screw-in interior threading 3 on the opposite end of the housing 1.

An adjustment piston 17 forming the seat element of the non-return valve is mounted in the cylindrical housing section 9 between the adapter 13 and the interior threading 3 so as to be axially displaceable. The adjustment piston 17 is sealed off from the cylinder wall of the valve housing 1 in both of its axial end areas by means of O-rings (not shown) seated in annular grooves 19, so that the fluid passage 7 is also sealed off from slot openings 21 which extend through the wall of the valve housing 1. The slot openings 21 which extend in the axial direction make available an axial displacement path for the control pins 23 which, diametrically opposite each other, extend through the slot opening 21, are seated in radial blind holes 25 of the adjustment piston 17, and by their outer end project beyond the exterior wall of the valve housing 1. The sections of the control pins 23 projecting to the exterior are situated between two positioning nuts 27 which are screwed onto exterior threading positioned on the housing section 9.

The adjustment piston 17 is slightly stepped on its exterior and is configured geometrically such that the O-rings seated in the annular grooves 19 are not damaged when it is installed in the valve housing 1.

The adjustment piston 17 has a coaxial interior passage 29 the edge of the opening of which facing the screw-in interior threading 3 forms a valve seat 31 in the form of a conical surface which interacts with a corresponding valve cone 33 on the detent element 35.

The detent element 35 is mounted so as to be axially displaceable on a guide element 37 which has a guide pin 39 which is concentric with the longitudinal axis 5 and is engaged in a concentric blind hole 41 in the detent element 35. On the end facing away from the guide pin 39 the guide element 37 has arms 43 extending radially, the radially exterior edge of which is provided with exterior threading by means of which the guide element 37 is anchored on the interior threading 3 of the valve housing 1. A helical compression spring 45 generating the closing force by which the valve cone 33 of the detent element 35 is pressed against the valve seat 31 on the adjustment piston 17 is mounted between the arms 43 of the guide element 37 and the thickening of the detent element 35 forming the valve cone 33.

The figure illustrates the adjustment position of the adjustment piston 17 serving as seat element in the position corresponding to the lowest opening pressure. If axial displacement of the adjustment piston 17 upward (corresponding to the figure) is effected by rotation of the positioning nuts 27 by way of the control pins 23, the detent element 35 is moved along against the closing force of the compression spring 45, so that the spring tension and accordingly the closing force are increased. The adjustment path of the adjustment piston 17 and accordingly the greatest possible opening pressure which may be set are defined by the axial length of the slot openings 21. It is essential for the length of the blind hole 41 into which the guide pin 39 of the guide element 37 is introduced to make an adequate guide length available, so that an adequate

displacement path of the detent element 35 is still available for the opening stroke even when the adjustment piston 17 is in the end position of the displacement path.

The non-return valve claimed for the invention offers an axial fluid passage, so that, since no rerouting of the flow is required, no problems resulting from depositing of particles need be feared if fouled fluids are involved. The structural elements of the non-return valve may be made of stainless steel, so that the valve is also suitable for aggressive media. A position marking or scale may be mounted on the exterior of the valve housing 1 in order to provide a display of the position of the adjustment piston 17. The valve may be preset for desired opening pressure values if calibrated markings or scales are present.